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Who writes the pay slip?
Do R&D subsidies merely increase researcher wages?

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Do R&D subsidies merely increase researcher wages?

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Abstract

Government intervention in private R&D activity is common practice nowadays. However, its impact may not be unambiguously positive. First, companies may simply replace private R&D budgets with the public R&D grant. Second, even if an increase in private R&D investment is confirmed, it may not automatically induce more R&D output: the additional R&D budget may be crowded out by duplicate or more risky research, or a mere increase in researcher wages.

This paper empirically analyzes the effect of public R&D subsidies on private R&D investments, employment and wages in Flanders, using a parametric treatment effects models on the funding status as well as IV regression models on the amount of funding. Positive additionality effects are supported, measured in terms of R&D expenditure, employment and wages. However, partial crowding out cannot be rejected.

Keywords: R&D subsidies, R&D expenditure, R&D employment, R&D wages, policy evaluation, treatment effects model, IV model

JEL-Classification: C21, H50, J20, J24, O38

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1. Introduction

R&D activity fosters economic growth (Romer, 1990) and is crucial in every modern economy these days. However, R&D is a high-risk activity entailing a substantial level of uncertainty (Dasgupta and Maskin, 1987). Large R&D investments may not (immediately) lead to results which contribute significant value to a company (Rosenberg, 1974). One of the main concerns of R&D managers therefore is to attract qualified and motivated personnel, apt to conduct R&D activities with a considerable degree of success. The lack of qualified personnel is an important bottleneck, seriously hampering innovative activity (Eurostat, 2004 as well as Mohnen et al., 2008). Moreover, sooner or later, knowledge created in the R&D process becomes available to other companies, which have the opportunity to free ride and exploit this knowledge (Arrow, 1962). Mobility of R&D personnel is one of the main factors explaining (un)desired spillovers between companies (Mansfield, 1985). Maliranta et al. (2008) mitigate this effect though, as they find that most of the knowledge which is transferred by employees, is knowledge which can be easily copied and implemented without substantial additional R&D efforts. An adequate remuneration therefore is crucial to attract, stimulate and retain highly competent R&D personnel. Earnings are an important determinant in the remuneration system, although also intrinsic motivations like job satisfaction and exciting job opportunities matter (Coombs and Gomez-Mejia, 1991). Researcher wages consume the lion's share of the total R&D expenditure of a company.

An adequate remuneration system may attenuate the free-rider problem, but also the government can play an important role through public intervention. Because of the negative externalities (see e.g. Arrow, 1962) in the R&D process, companies are expected to invest less than what is socially desirable and as a consequence some projects, despite their significant social benefit, will not be executed. An R&D subsidy lowers the cost of a private R&D project and possibly alters its outcome into an expected net profit, resulting in a positive decision to conduct the project. Subsidies for R&D projects by now have become a well-established government intervention tool in the private R&D sector. However, companies may well replace their own, private money with the grant they received from the government, which would in the end not increase total private R&D expenditures. Empirical research on this crowding-out hypothesis is vast (see e.g. Aerts et al., 2007 for a survey of the empirical evidence) and many researchers reject, while others support it. However, as David and Hall (2000) suggest: 'the more the better' is a questionable statement when it comes to R&D expenditure. Mere R&D expenditures may not constitute an adequate measure to evaluate the effectiveness of R&D subsidies. They advise to introduce the close interconnectivity between scientific labour markets and R&D investment decisions into the evaluation process of public R&D policy. Goolsbee (1998) came to the conclusion that R&D subsidies are primarily translated into researcher wage increases, inflating positive additionality effects by 30% to 50%. Wallsten (2000) and Suetens (2002) agree as their data refute the argument that R&D subsidies stimulate the demand for R&D personnel. Yet other researchers find positive estimates for increases in the R&D staff due to a subsidy (Üçdoğruk, 2004; Ali-Yrkkö, 2005; as well as Reinthaler and Wolff, 2004).

This paper empirically analyzes the effect of public R&D subsidies on private R&D investments, employment and wages in Flanders, employing parametric treatment effects models and IV methods. In the next section, the relevant literature will be discussed. Subsequently, I come to a brief explanation of the econometric methods underlying the empirical evidence. After a description of the data in the fourth section, the estimation results are presented and subsequently discussed in the two last sections.

2. Literature Review

The evaluation of public R&D policy has been extensively addressed in empirical research. David and Hall (2000) conclude in their review of evaluation studies on innovation input that the results on potential crowding-out effects are ambiguous, and they criticize that most existing studies neglect the problem of sample selection bias: it is not implausible that an endogenous relationship exists between R&D investments and the receipt of public R&D grants. On the demand side of public funding, R&D intensive firms may well be more likely to apply for a subsidy: they are more apt to market their project as being highly interesting for society and exhibiting a high expected rate of success. Moreover, they may be better acquainted with the eligibility criteria and the procedures to apply for a subsidy. On the supply side of the public funding system, the government may just as well be more inclined to grant them a subsidy, as R&D intensive firms exhibit a higher expected rate of success. This makes R&D funding an endogenous variable, which may seriously distort evaluation results. In the next section, I expound on the methodological consequences of this endogeneity problem. More recent research takes this potential sample selection bias into account through selection models, instrumental variable (IV) estimations (including simultaneous equation systems), difference-in-differences estimations and matching techniques. So far, Austria, Denmark, Finland, Flanders, France, Germany, Ireland, Israel, Norway, Spain, Sweden and the US have been subject to an R&D input evaluation analysis of their public R&D funding system. These studies tend to reject full crowding-out effects but the results are ambiguous[1]. Key reasons for these diverging conclusions are the use of different estimators, as well as the application for a broad range of countries, each with their own specific S&T policy (David and Hall, 2000).

However, more private R&D investments do not necessarily translate into more R&D output. Moreover, even if an increase in private R&D activity is confirmed, it may not be beneficial for the society. Inefficiencies may rise from duplicate research (Irwin and Klenow, 1996 as well as David and Hall, 2000), though Dasgupta and Maskin (1987: 582) state that "*parallelism need not imply waste*". The additional R&D budget may be allocated to more risky and therefore potentially less successful projects (Setter and Tishler, 2005). Romer (2000) denounces the mismatch between policy measures stimulating the private demand for scientists and engineers and the incapability of the educational system to provide a positive supply response. Consequently, David and Hall (2000) advocate the introduction of labour market dynamics into the additionality issue.

Although the development of econometric methods (see Heckman et al., 1997 and Heckman et al., 1999 for a survey) to counter the difficulties in measuring the effectiveness of policy programs originated in labour market economics (the

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[1] Aerts and Czarnitzki (2004 and 2006), Aerts and Schmidt (2008), Ali-Yrkkö (2004), Almus and Czarnitzki (2003), Clausen (2007), Czarnitzki (2001), Czarnitzki and Fier (2002), Czarnitzki and Hussinger (2004), Duguet (2004), Ebersberger (2005), Fier (2002), González and Pazó (2006), González et al. (2005), Görg and Strobl (2007), Hussinger (2008), Hyytinen and Toivanen (2005), Lööf and Heshmati (2005) and Streicher et al. (2004) reject full crowding-out effects, while Busom (2000), Heijs and Herrera (2004), Kaiser (2004), Lach (2002), Suetens (2002), Toivanen and Niininen (2000) as well as Wallsten (2000) find indications that public R&D funding replaces private R&D investments to some extent. The interested reader is referred to Aerts et al. (2007) for a survey of the recent literature on the evaluation of public innovation policy.

evaluation of labour programs including public job training and active labour market policies), the main research issue in additionality research of R&D subsidies became to find out how much more private R&D investments were made, due to the provision of public money for private R&D activities. The impact on the R&D workforce has been ignored to a large extent.

To the best of my knowledge, only a limited number of studies explores this research path, either on the macro (Reinthaler and Wolff, 2004) or micro (Goolsbee, 1998 for individuals and Wallsten, 2000; Suetens, 2002; Üçdoğruk, 2004 and Ali-Yrkkö, 2005 for firms) level. The empirical evidence is not unanimous, however. One explanation can be found, by analogy with diverging results in the more traditional R&D additionality research, in the use of different datasets, covering different regions and time windows and the application of various methodologies. Another explanation is the behaviour of the inputs of the R&D process, including the supply of R&D personnel. Different hypotheses are put forward in the literature, predicting the elasticity of the supply of researchers and their wages. A subset of the studies mentioned above additionally substantiates proof on the impact of public R&D funding on R&D wages (Goolsbee, 1998; Reinthaler and Wolff, 2004; Üçdoğruk, 2004 and Ali-Yrkkö, 2005). An overview of the main characteristics of these articles is presented in Table 1. In the following subsections a synopsis of the literature on additionality effects on R&D employment as well as R&D wages is presented and the hypotheses, which will be tested in the empirical part, are derived.

Table 1: The impact of public R&D funding on employment and wages: literature overview

Author(s)	Country	Funding source	Time window	Unit of observation	Sample size	Methodology	Dependent variable	Impact of R&D subsidies on: R&D employment	R&D wages	R&D labour supply elasticity
Ali-Yrkkö (2005)	Finland	Tekes	1997-2002	firms	187 (panel)	employment equation IV	R&D employment	+	+	
Ebersberger (2004)	Finland	Tekes	1996-2000	R&D active firms	?	Kernel matching difference-in-differences	(R&D) employment*	0	0	large
Goolsbee (1998)	US	Federal R&D expenditure	1968-1994	scientists and engineers	17,700	OLS	income wages hours worked	0	+	very low
Reinthaler and Wolff (2004)	OECD countries	public R&D expenditure	1981-2002	countries	15 (panel)	fixed effect panel regressions	R&D employment and wages	+	+	low, but larger than Goolsbee's estimate
Seutens (2002)	Flanders	regional, national, EU government	1992-1999	innovative (large) firms	262 (panel)	production function with R&D equation IV	R&D employment	0		
Üçdoğruk (2004)	Turkey	TTGV	1993-2000	manufacturing R&D active firms	314 (panel)	labour demand function	R&D employment	+	+	
Wallsten (2000)	US	SBIR	1990-1993	SBIR small high-tech firms	481	IV-3SLS	(R&D) employment*	0		

*Note: although Wallsten (2000) measures the impact on total employment in a dataset of small high-tech SBIR funded firms, he (2000: 89) signals that "*most employees in these small firms are likely to be scientists, engineers, or others who are directly involved in R&D*". Also Ebersberger (2004) studies the impact on firms' employment. However, he adds that, as the subsidy program under investigation targets R&D activities, the impact of the program can be evaluated in terms of R&D labour demand. Therefore, I consider their studies being comparable with the other studies listed, which explicitly measure the impact of public R&D funding on R&D employment.

2.1. Public R&D funding and R&D employment

Applying fixed effect panel regressions on a panel dataset containing data on 15 OECD countries from 1981 to 2002, Reinthaler and Wolff (2004) estimate positive additionality effects for R&D investments, as well as a smaller, but still significant increase in national R&D employment. Goolsbee (1998) investigates survey data on the income of 17,700 scientists and engineers in the U.S. from 1968 to 1994. He relates the total and federal R&D expenditure to income as well as wages and hours worked in an OLS framework. The impact of federal R&D expenditure on the number of hours worked is not significant.

Suetens (2002), Üçdoğruk (2004) and Ali-Yrkkö (2005) all apply a production function framework, taking information on subsidy receipt into account. Suetens (2002) uses panel data on Flemish firms observed between 1992 and 1999 to estimate an R&D personnel equation and an output (added value) equation with instrumental variables and finds that crowding-out effects cannot be rejected offhand. Üçdoğruk (2004) employs a panel dataset on Turkish R&D active manufacturing companies, observed between 1993 and 2000. She concludes that R&D support programs significantly increase the demand for R&D personnel, especially for researchers holding a graduate degree. However, she does not correct for the potential endogeneity bias embodied in the relationship between the demand for R&D personnel and public R&D funding. In his set of Finnish firms, observed between 1997 and 2002, Ali-Yrkkö (2005) estimates significantly positive effects on R&D employment.

Wallsten (2000) and Ebersberger (2004) present two studies which are closely related to this research issue and which are therefore included as well. Wallsten (2000) evaluates the impact of US SBIR grants to small high-tech firms on their total employment in an IV approach. Although this funding is not explicitly intended to support R&D activities, the author signals (Wallsten, 2000: 89) that "*most employees in these small firms are likely to be scientists, engineers, or others who are directly involved in R&D*". He finds that larger firms are more likely to receive a grant, but additionality effects on employment cannot be confirmed. Ebersberger (2004) investigates the impact of two-year grants, allocated in 1996, on the total labour demand in Finnish companies employing matching and difference-in-differences methods. He claims that, as the subsidy program under investigation targets R&D activities, the impact of the program can be evaluated in terms of R&D labour demand. His estimates demonstrate no significant impact. From this review of research on R&D subsidies and R&D employment, it becomes clear that the evidence is mixed: both neutral as well as positive effects are found.

Two elements may introduce some dynamics into the subsidy-employment relationship. First, increased R&D investments due to a subsidy may stimulate company growth and only in a second phase lead to increased R&D employment. See e.g. Chennels and Van Reenen (1999) for a survey of studies on the impact of technological change on employment. Second, as Reinthaler and Wolff (2004) suggest, technology spillover effects may exist: a subsidy may induce the development of a new technology, which nevertheless draws heavily on knowledge incorporated in existing technologies, and may therefore stimulate other firms to build on that technology. As a result, one could expect that the impact of public R&D funding is larger in the long than in the short run. Positive long-run effects on R&D employment are found by Lerner (1999), Ebersberger (2004) as well as Reinthaler and Wolff (2004).

2.2. Public R&D funding and R&D wages

R&D wages absorb a significant share of the total R&D expenditure (e.g. in Flanders on average around 67% in Czarnitzki et al., 2006). Therefore, also the cost of the input factor of R&D personnel, i.e. R&D wages, plays an important role in additionality research on R&D employment: R&D wages may adversely interact with Science and Technology policy measures introduced by the government. This may provide a sound explanation to why the publicly induced increase in R&D staffing does not keep up with the induced increase in R&D expenditure.

Reinthaler and Wolff (2004) observe a simultaneous increase in national R&D investment and R&D employment. The increase of the R&D staff is smaller, though, which brings them to the conclusion that also scientists' wages experience an increase. Goolsbee (1998) concludes that increases in R&D expenditure are mainly allocated to researcher wages and not to research effort. Ebersberger (2004) claims that the Finnish innovation system provides an adequate inflow of researchers, and that therefore an increase in R&D investments is fully absorbed by an increase in R&D employment, but he does not put his statement to the test. This is however done by Ali-Yrkkö (2005), who concludes that R&D subsidies have, in addition to a positive effect on the number of R&D employees, also a significantly positive effect on researcher wages. Üçdoğruk (2004) finds indications that in Turkey, R&D subsidies significantly increase researcher wages. So, although there is substantial ambiguity concerning the impact of R&D subsidies on R&D employment, there is consensus on the fact that researcher wages increase when a company receives an R&D subsidy.

Also few attempts have been made to assess the impact of R&D tax credits on private R&D wages. Although in this paper, the explicit focus is on direct R&D funding, the main results are briefly mentioned. Marey and Borghans (2000) estimate the wage effect of R&D tax incentives in the Netherlands and estimate average elasticities of R&D wages to the total sectoral R&D expenditure of 0.52 in the short run and 0.38 in the long run. Lokshin and Mohnen (2008) estimate a short run elasticity of 0.10 and a long run elasticity of 0.12 in the Netherlands. Haegeland and Møen (2007) assess the Norwegian R&D tax credit measure and estimate an elasticity of 0.33.

The latter studies typically conclude that the increase of R&D wages provokes a significant inflation problem in additionality research: it is criticized that a substantial part of the subsidised money dissipates, as it perishes into mere R&D wage increases, without any actual impact on R&D activity. Goolsbee (1998) estimates that, as a result of R&D wage increases, additionality effects of R&D subsidies may be overestimated by 30% to 50%. The indirect impact of this wage increase may be even worse, since an increase in researcher wages may also affect non-funded firms, as they have to downsize their R&D activity (Goolsbee, 1998 and Hinloopen, 2004).

Inelastic labour supply

The argument of inflated additionality effects is typically based on the underlying hypothesis that the supply of R&D personnel is inelastic. An inelastic labour supply increases the search costs for competent scientists and engineers and strengthens the bargaining power of R&D employees in wage negotiations (Lokshin and Mohnen, 2008).

Goolsbee (1998) provides evidence that the supply of scientists and engineers is relatively inelastic. Reinthaler and Wolff (2004) make a stand against a priori expectations about the elasticity of the R&D labour supply. An elastic supply curve can be expected when considering the large pool of university graduates available to R&D companies on the one hand and the number of researchers actually employed as R&D staff on the other hand. Lundborg (2005) concludes that supply is not a restrictive variable, as the underutilization of potential R&D employees is substantial. However, Goolsbee's findings (1998) on an inelastic labour supply curve are not unrealistic when R&D is performed by thin on the ground experienced and highly specialized scientists. Trajtenberg (2000) also claims that shortages of highly skilled personnel in cutting edge technologies are a pervasive phenomenon in Israel. By contrast, Ebersberger (2004: 22) rejects the existence of this problem in Finland, as "*the Finnish innovation system has been able to constantly increase the supply of science and technology graduates*". The reader should bear in mind however, that Goolsbee (1998) runs his analysis on survey data on the income of scientists and engineers, including both public and private R&D staff. One could expect that the researcher supply elasticity is highly dependent on the sector. Research in universities versus companies may require and/or attract a different kind of researcher. Reinthaler and Wolff (2004) compute elasticities of the labour supply in 15 OECD countries. Their estimates are rather low, but significantly larger than the estimates of Goolsbee (1998). They find an additional explanation for a potential underestimation of the labour supply elasticity in Goolsbee's exercise (1998) in the fact that he uses data from a period exhibiting extraordinary government intervention. Moreover, the supply elasticity is measured in a different way: Goolsbee (1998) calculates the increase in the average working time in reaction to higher wages, while Reinthaler and Wolff (2004) also allow for the additional employment of R&D workers.

Upskilling process

Nevertheless, Goolsbee's (1998) pessimism may be alleviated, as R&D wage increases do not necessarily equate a loss of R&D effort. For example, in a general employment context, Merito et al. (2007) test the impact of public funding and record positive effects on SME wages on the short (two years) and long term (four years) and conclude that the simultaneity of increased R&D staffing and higher wages signals an 'upskilling' process: the employment structure is shifted towards more skilled employees. Katz and Murphy (1992) also found that rapid growth in the demand of skilled workers appears to be the driving force behind changes in the wage structure. Translated into an R&D environment, this would render the R&D effort of an equally large R&D staff more efficient. Moreover, the population of (potential) R&D employees is not homogeneous. Zucker and Darby (1996: 12709) state that "*scientific breakthroughs are created by, embodied in, and applied commercially by particular individuals responding to incentives and working in specific organizations and locations*". As a result, in high-tech firms intellectual capital of key personnel is far more important than physical assets (Darby et al., 1999). Therefore, partial or even full crowding-out of additional R&D investments into higher wages is not necessarily bad: if companies are able to allocate a larger budget to their human capital, this may strengthen their power in the competition to attract top researchers.

Determinants of R&D wages

Wage dispersion may originate in employee as well as employer specificities. Individual worker characteristics, among which gender and age are most important, determine a significant share of wage dispersion. Also, considerable disparities in the pay slip are due to differences in the workplace. A large share of the literature on wages focuses on the positive correlation between company size and wages as well as the impact of sector affiliation. Larger companies typically write higher pay slips. Different explanations can be found: higher wages may serve as a compensation mechanism for a more complex working environment in larger companies; act as an instrument to increase the workforce's motivation; or reflect differences in the composition of the workforce. Heterogeneity in the composition of the workforce, generating a larger share of skilled workers in the larger firms, can originate in different capital intensities (skilled workers work in more capital intensive sectors; larger companies are typically more capital intensive), scale advantages (employing skilled workers implies a substantial amount of fixed costs), the hierarchical structure (larger companies are structured more hierarchically, requiring the employment of more managers) and the employees' seniority (larger companies can offer more promotion and education possibilities and face a lower risk of bankruptcy, implying a higher level of seniority and subsequently higher wages) (Plasman et al., 2008).

Next to size, also sector affiliation is found to drive a significant share of wage differences (see Plasman et al., 2008). A growing body of the literature investigates the underlying reasons behind this strong correlation. First, the weight of wage bargaining differs significantly between the sectors. In some sectors (e.g. sectors with a large share of small companies), sectoral bargaining is absent and wages are settled at the company level. Furthermore, some sectoral agreements only determine minimum wages, as increases in the actual wages are only negotiated at the company level. Therefore, a strong centralization of the wage bargaining process reduces wage differences. This argument is strongly linked with the second: different sectors exhibit different productivity and profit levels (Plasman et al., 2006). Moreover, differences in the way the profit gains are redistributed in the company also drive inter-firm wage differences. Rusinek and Rycx (2008) find that, the more this redistribution occurs on the company level, the larger the wage differences become. A last argument is the power of unions: they can put pressure on companies to increase the wages and close sectoral wage gaps.

In this paper we specifically look at R&D wages in the private sector. Typical factors influencing the general average wage level and dispersion are expected to play here, too, and interact with the factors explaining R&D activity. First, size seems to be an important driver of inter-firm[2] R&D wage differences: the annual R&D expenditure per R&D employee increases significantly with firm size (Czarnitzki et al., 2006). Also sector affiliation interacts with R&D wages. The annual R&D expenditure per R&D personnel and the share of personnel costs in the total R&D expenditure vary over the different sectors (Czarnitzki et al., 2006). Capital intensity is expected to have an impact, as well as the share of highly skilled employees. Productivity and, more specifically, R&D productivity may be correlated positively with R&D wages, as well as the level of international competition, and (foreign) group membership. Last, also the scope of the union's

[2] As only information about the average R&D wage is available, intra-firm R&D wage dispersion can not be investigated. It is beyond the scope of this paper, but remains an interesting and challenging issue for further research.

power in the wage bargaining process may generate inter-firm R&D wage differences.

2.3. Hypotheses

In the empirical part of this paper, I first assess the impact of public R&D funding on private R&D expenditure. In the next step, the typical testing of the crowding-out hypothesis in terms of R&D expenditure is extended with respect to the R&D workforce: if a subsidy stimulates private R&D expenditure, does this publicly induced increase in R&D expenditure generate additional R&D employment? In the last step, the wage structure is analysed with respect to R&D subsidies.

The literature shows that long term effects may be significantly different from the effects found in the short run. However, this paper focuses on the short term effects; potential long term effects are beyond its scope and left for further research.

3. Selectivity issue

This section will explain more in detail the nature of the endogeneity problem, which may distort estimation results of the relationship between public R&D funding and R&D activity. Next, I briefly explain the methodology which will be employed to eliminate the potential bias caused by this selectivity problem.

The outcome variable Y (e.g. R&D expenditure, R&D personnel, etc.) can be modelled as follows[3]:

$$Y = \begin{cases} X\beta + S\alpha + U & \text{if } S = 1 \\ X\beta + U & \phantom{\text{if }} S = 0 \end{cases}, \qquad (1)$$

where X represents a set of exogenous variables and β their respective parameters. S refers to the treatment status (S=1: treated; S=0: untreated – treatment is the receipt of a subsidy in this case) and α measures the impact of this treatment. *U* is the error term with zero mean and U is assumed to be uncorrelated with *X*. However, it is not unlikely that U is correlated with S: subsidized companies may well be more R&D active than the non-subsidized companies, even without the subsidy program. R&D

[3] I omit firm indices for the sake of readability.

intensive firms may be more likely to receive an R&D subsidy as governments aim at maximizing the probability of success and therefore may well cherry-pick proposals of companies with considerable R&D expertise. Moreover, it is also quite possible that only particular companies apply for public R&D grants because they have an information advantage and are acquainted with policy measures they qualify for. In an experimental setting, without any selection bias and random subsidy allocation, U and S are not correlated. This is most likely not the case in current innovation policy practice, though. This would imply a selection bias in the estimation of the treatment effect. Therefore, standard econometric approaches, regressing Y on X and S by OLS, are not valid and other approaches, taking this potential endogeneity properly into account, should be employed. Econometric literature has developed a range of methods (see e.g. the surveys of Heckman et al., 1999; Blundell and Costa Dias, 2000, 2002; Aerts et al., 2007). Examples of these methods are difference-in-differences estimations, matching, selection models and instrumental variable (IV) estimations (including simultaneous equation systems). I will apply the latter two methods in the empirical part. In the following paragraphs they are very briefly explained.

The subsidy allocation can be modelled by the following selection equation:

$$S^* = Z\gamma + V\,, \tag{2}$$

where S* is an index, measuring the probability to receive public funding, depending on a set of company characteristics Z and their respective parameters γ, as well as an error term V. When S* is positive, the company is granted a subsidy:

$$S = \begin{cases} 1 & \textit{if } S^* > 0 \\ 0 & \textit{otherwise} \end{cases}. \tag{3}$$

The two-step selection model estimates two equations. A discrete choice model predicts the probability of being treated (S*) (the selection equation) and the outcome variable is regressed linearly on the treatment variable, controlling for observable exogenous characteristics (the outcome equation). Theoretically, the outcome equation is defined through the nonlinearity of the hazard parameter (also labelled as the inverse Mills ratio). However, in practice, most observations are located within the quasi-linear range of the hazard parameter (Puhani, 2000). Hence, to identify the treatment effect, an exclusion restriction is imposed. This requires the existence of at least one variable, which is insignificant in the outcome equation, but at the same time significant in the selection equation. This regressor should not be correlated with the error term V of the selection equation. The selection model directly controls for the part of the error term U which is correlated with S. It is commonly assumed that U and V follow a joint normal distribution[4], resulting in the following conditional outcome equations:

$$\begin{aligned} E(Y|S=1) &= X\beta + \alpha + \rho\phi\left(\frac{Z\gamma}{\sigma_V}\right)\Phi\left(\frac{Z\gamma}{\sigma_V}\right)^{-1} \\ E(Y|S=0) &= X\beta - \rho\phi\left(\frac{Z\gamma}{\sigma_V}\right)\left[1-\Phi\left(\frac{Z\gamma}{\sigma_V}\right)\right]^{-1} \end{aligned}, \tag{4}$$

where the last term in each equation represents the error term conditional on S. An important advantage of this methodology over matching lies exactly here: by separating the impact of S from the selection process, any correlation with unobserved variables is corrected for.

This model has often been criticized as it is quite demanding on assumptions about the structure of the model. Therefore, the evaluation of the funding status is introduced in an IV framework. Moreover, while the application of treatment effects models is limited to binary treatment only, IV regressions allow refining the impact of the measure in a continuous treatment set-up[5]. This will provide a further robustness check, as here not only the funding status, but now also the funding amount is taken into account.

An instrument Z* is defined and a transformation g is applied, satisfying the requirement that g(Z*) is uncorrelated with U conditional on X, and that Z* is not completely determined by X. Unlike the selection model, IV is a simpler estimator as it omits the selection equation estimation. However, its major drawback lies in the identification of the instrument Z*: it has to be valid as well as relevant. Only in that case, the estimates will be consistent. Overidentifying restrictions are tested by the Hansen-Sargan test. Its joint null hypothesis claims that the instruments Z* are valid, i.e. uncorrelated with the error term U, and that the excluded instruments are rightfully excluded from the estimated equation. The identification of the equation, i.e. whether the excluded instruments are relevant, is tested in the Anderson

[4] The assumption of joint normality of U and V can be relaxed, though. The interested reader is referred to Hussinger (2008).

[5] Most frequently, IV regressions are applied on discrete treatment variables. However, the same procedure is valid for continuous treatment variables (see e.g. Wooldridge, 2002).

canonical correlations likelihood-ratio test. Its null hypothesis is that the equation is underidentified. Consequently, the potential endogeneity is adequately corrected for, if the Hansen-Sargan test holds and the Anderson canonical correlations likelihood-ratio test is rejected. Moreover, compliance with the Stable Unit Treatment Value Assumption (SUTVA) is required: the treatment of one firm should not affect the treatment effect on another firm (Rubin, 1990). Unfortunately this cannot be tested.

4. The data

This section first sketches the contextual framework. Next, I come to a description of the data and the variables which are employed in the empirical part.

4.1. Contextual framework

The particularities of public R&D funding and the process of wage settlement in Flanders are briefly explained.

Public R&D funding in Flanders

In Flanders, IWT, the Institute for the Promotion of Innovation through Science and Technology in Flanders, is the single counter where companies can apply for a subsidy. This implies that subsidies, at the Flemish and Belgian level, as well as certain EU-funded projects[6] are evaluated and granted through IWT. Accelerated depreciation for R&D capital assets and R&D tax allowances are available through the federal Belgian government. In contrast to most countries, the Belgian R&D tax allowances are fixed and not granted as a percentage: for each additional employee employed in scientific research, the company is granted a tax exemption for a fixed amount, in the year of recruitment. However, as Van Pottelsberghe et al. (2003) indicate, very few Belgian companies actually make use of these fiscal measures[7]. Main reasons are a low level of acquaintance with the

[6] The Framework Program projects are not managed through IWT. However, typically the scale of these projects is very large because these projects are often managed in international company consortia. As a result, the number of Flemish firms engaging in these programs is very limited.

[7] Due to recent changes in the Science and Technology Policy, this situation has changed, though. In the current system, fiscal measures, and more specifically tax credits for R&D personnel, are becoming increasingly popular. However, this is not relevant in the current paper, as our data was collected before the change.

system, complexity and high administration costs[8] and the fact that the measures are not significantly substantial[9]. Direct R&D funding through IWT remains the largest source of public R&D grants in the private sector in Flanders[10].

Wage settlement in Flanders

In Flanders, wages are typically settled through collective bargaining. This usually occurs hierarchically, on three levels, which implies that bargaining at lower levels can only affect wages upwards (Plasman et al., 2007). At the top level, wages are settled through inter-sectoral agreements at the national level: minimum wages are fixed, as well as a margin for wage increases. Second, additional sectoral agreements may be negotiated, setting industry standards (minimum wages by category of worker) for most of the employees in the industry concerned. Finally, in a third bargaining round, single-employer agreements may be settled at the firm level. The bargaining process at the firm level has gained importance over time. Strong wage increases may reduce the national competitiveness and hence also reduce employment rates. Therefore, the government froze the private-sector wages several times; e.g. in 1996, a wage standard was introduced, imposing an upper limit to wage increases, coupled to the wage margins in France, Germany and the Netherlands. However, international comparisons reveal that labour is still significantly expensive in Flanders. Nevertheless, wage settlement in Flanders is far from a centralized and tight system and leaves considerable margin for inter-firm wage dispersion; Anglo-Saxon countries exhibit higher dispersion rates, while wages are distributed more equally in the Scandinavian countries (Plasman et al., 2008).

4.2. Variables

The potential crowding-out effect of R&D subsidies in Flanders is addressed empirically with data from the biannual Research and Development Survey. This mainly quantitative survey covers most EU countries with a by and large

[8] First, each year the company has to deliver a certificate. Second, the researcher should be full time employed in the research department of the same company to qualify. Third, the tax allowance is nominative, inducing a burden to keep track of all employees who benefited from the measure in the past.
[9] First, the amount of the exemption is not sufficiently significant. Second, the definition of highly qualified personnel is too strict, so that only very few employees qualify for the measure. Third, the tax exemption is a short term measure (it only relates to the first year of recruitment) while R&D typically is a long term process.
[10] The interested reader is referred to Aerts and Czarnitzki (2006) for a detailed overview of the public R&D funding system in Flanders.

harmonized questionnaire and the collected data are, among other things, used to compose the European Innovation Scoreboard (see e.g. PRO INNO EUROPE, 2008). The set-up of the Flemish R&D survey is inventory-based: all potentially R&D active companies are identified and surveyed. In terms of R&D expenditure, the collected data cover a sample of companies, which are, in total, responsible for about 80% of the total R&D expenditure in Flanders (Debackere and Veugelers, 2007). Therefore, the sample is close to the population of all R&D active companies in Flanders. I pool two consecutive waves, i.e. the 2004 and 2006 R&D surveys[11]. The R&D data are supplemented with patent application data from the European Patent Office since 1978. Balance sheet data from the National Bank of Belgium (Belfirst) was merged to the dataset to provide financial indicators. Last, information on the subsidy size and history of each company was added: IWT keeps track of all subsidy applications and potential subsequent grants.

The receipt of subsidies is denoted by a dummy variable (FUN) indicating whether the firm received public R&D funding. The amount of subsidies received is measured by AMT (in million EUR). No distinction is made with respect to the source which provided the public funding; the impact is an average effect over the different funding schemes.

The outcome variables reflect a company's R&D[12] activities. First, I test the impact of an R&D subsidy on R&D expenditure (RDX, in million EUR). As the distribution of RDX is highly skewed, the R&D expenditure intensity, RDXint (RDX / turnover * 100) is included as well. Second, I test how the R&D staffing changes when a subsidy is granted to a company. RDP is the number of R&D personnel (in full time equivalents, or FTEs). Again, to complete the picture of the impact of R&D subsidies on R&D activities in spite of the skewed distribution of R&D activities, R&D personnel intensities are calculated: RDPint (RDP / total number of employees * 100). The third set of outcome variables disentangles a company's R&D expenditure into the share allocated to personnel costs on the one hand and the share allocated to all other costs (investments and operational costs) on

[11] The data collected in the surveys refer to the period 2002-2004 (2004 survey) and 2004-2006 (2006 survey). The funding variables are measured in 2003 and 2005, respectively. To avoid endogeneity problems in the selection equation, the covariates are measured, whenever possible, at the beginning of the reference period. Only R&D active companies are kept for the analysis.

[12] R&D is defined in accordance with the Frascati Manual (OECD, 2002: 30): "*creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications*".

the other hand. These variables are normalized by the number of R&D employees. Hence, RDX_P/RDP reflects the company's R&D wage structure. RDX_O/RDP measures the R&D expenditure per R&D employee, leaving out the personnel costs. These variables will allow us to test whether potential additionality effects on the R&D expenditure are partially or fully absorbed by an increase in R&D staff wages. In that case, the effectiveness of the public R&D funding system could be questioned. The Flemish R&D activities are highly skewed. That is why one should also consider the logarithmically rescaled values of the measures of R&D activity: lnRDX and lnRDP; of course, also the amount of funding is rescaled in these models (lnAMT).

In the literature on additionality assessment of public R&D funding, different authors have used different sets of exclusion restrictions and instrumental variables. Busom (2000) introduced selection models in additionality research and used the age of the company, reflecting its overall experience, as an exclusion restriction. She argues that more experienced firms are more aware of the value of innovation and may write better project proposals, both increasing the likelihood of receiving a subsidy. Kaiser (2004) uses a set of dummies reflecting competition (local, national or multinational orientation), ownership ((partly) publicly owned) and cooperation behaviour (external partners or academia involved in new product or process development). He argues that the firm may not care where the competition comes from, while governments may want to strengthen the technological competitiveness of domestic firms in the perspective of foreign competition. Moreover, the explicit policy aim of the Danish government to foster R&D cooperation may increase the likelihood that R&D cooperation projects are publicly funded. Ebersberger (2005) uses the share of R&D employees as exclusion restriction; as he uses a sample of innovative firms only, funding decisions have no influence on R&D status, but do influence the intensity of conducting R&D activity. Hussinger (2008) generates an artificial exclusion construct, including information on the legal form of the company, foreign ownership and the existence of an own R&D department within the company. Wallsten (2000) was the first to employ instrumental variable regressions. His instrument, the budget which is potentially available for a firm in a certain industry or technological area, has become very popular and was picked up by several authors (Hyytinen and Toivanen, 2005; Clausen, 2007 and Ali-Yrkkö, 2004 and 2005). Ali-Yrkkö (2004) additionally experimented with the amount of funding the company has applied for in the year of the funding receipt. Aerts and Czarnitzki (2006) use the number of past project applications. Suetens (2002) and Gonzáles et al. (2005) introduce the lagged value of the subsidy as instrumental variable in their regression.

Building on the existing research summarized above, I introduce two new variables. They are supposed to have an impact on the funding status, but not on the outcome. In the treatment effects model they serve as excluded explanatory variables in the outcome regressions, which are significant in the selection equation, though. In the IV-set-up, they provide a vector of instruments. They are computed from the company's subsidy history. AMT/PROJ_past5yrs (in million EUR) contains the total public R&D funding the company received in the preceding five years, divided by the number of projects in this period. PROJ/EMP_past5yrs (in number / FTE) is a count variable, reflecting the total number of project proposals per employee each company submitted in order to obtain an R&D subsidy in the preceding five years. These variables seem to be reliable instruments, since they are highly correlated with a company's current funding status but at the same time, the company's current R&D activity does not influence its subsidy history. To obtain the right fit in the estimate dimensions, also the logarithmic transformations of these variables (lnAMT/PROJ_past5yrs and lnPROJ/EMP_past5yrs) were used in the respective models.

I use several control variables which may affect both the subsidy receipt and R&D effort. Including the number of employees allows controlling for size effects, which are empirically often found to explain innovativeness (see e.g. Veugelers and Cassiman, 1999). Moreover, the Flemish S&T policy puts high value on R&D activities performed by small and medium sized companies. Therefore, the size variable is also expected to influence the subsidy receipt. The logarithmic transformation (lnEMP) is used to avoid potential estimation biases caused by skewness of the data.

Another important variable is the firms' patent stock (PAT). As I use data from two cross-sectional datasets, which do not include time-series information, the patent stock enables us to control for previous (successful) R&D activities. Obviously, not all innovation efforts lead to patents, which Griliches (1990: 1669) formulated nicely as "*not all inventions are patentable, not all inventions are patented*". Likewise, not all patented innovations result from R&D activities; the R&D process is only part of a company's innovative activity[13]. Moreover, the propensity to patent may be heterogeneous among firms. However, as data on previous R&D expenditure are not available, the patent stock is the best approximation of past innovation activities. I use all patent information in the EPO database and generate the stock of patents for each firm as the depreciated sum of all patents filed at the EPO from 1978 until 2001(1997):

$$PAT_t = (1-\delta)PAT_{t-1} + PATA_t \,, \tag{5}$$

where PAT is the patent stock of a firm in period t and t-1, respectively, PATA are the number of patent applications filed at the EPO and δ is a constant depreciation rate of knowledge which is set to 0.15 as common in the literature (see e.g. Jaffe, 1986; Griliches and Mairesse, 1984). On the one hand, firms that exhibit previous successful innovation projects indicated by patents, are more likely to receive public R&D funding, because public authorities may follow the 'picking-the-winner' principle in order to minimize the expected failure rates of the innovation projects, and hence, to maximize the expected benefit for the society. On the other hand, the patent stock controls for the past average innovative engagement of the firms, because it is expected that firms that were highly innovative in the past will continue this strategy. The patents are counted only until 2001(1997), to ensure that the stock definitely refers to past innovation activities, in order to avoid a simultaneous equation bias in the regression analysis. The patent stock enters into the regression as patent stock per employee (PAT/EMP) to reduce the potential multicollinearity with firm size.

The export quota (EXQU = exports / turnover) measures the degree of international competition a firm faces. Firms that engage in foreign markets may be more innovative than others and, hence, would be more likely to apply for subsidies.

Next, variables reflecting the technological and financial quality of the company may play a significant part in both the subsidy and R&D story. These characteristics are proxied by capital intensity (CAPint) as the value of fixed assets

[13] Innovative activity is defined as "*all those scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of technologically new or improved products or processes*" (OECD/Eurostat, 1997: 10).

per employee and cash-flow (CASHF) (both in million EUR) respectively. Both variables are obtained from balance sheet records provided by the National Bank of Belgium (through the Belfirst database). CASHF is also divided by the number of employees (CASHF/EMP) to avoid multicollinearity with firm size.

A dummy variable indicating whether a firm belongs to a group (GROUP) controls for different governance structures. Firms belonging to a group may be more likely to receive subsidies because they presumably have better access to information about governmental actions due to their network linkages. In addition to group membership, FOREIGN indicates whether this group is domestic or foreign-owned. Foreign affiliates may be more likely to apply for a subsidy in their home country. Twelve industry dummies (BR) are included to allow for differences between sectors. On the one hand, some sectors may exhibit a larger R&D intensity. On the other hand, governments may favour certain sectors in their R&D policy, which increases the likelihood of receiving subsidies for firms in these industries.

From the theoretical evidence on R&D wages, different factors are derived which could possibly drive inter-firm dispersion. Most of these are already reflected in the variables described above. Size (lnEMP) and sector (BR) may determine R&D wages. Also capital intensity is expected to have an impact. Productivity and more specifically R&D productivity may be correlated positively with R&D wages. This productivity is captured by the patent stock (PAT/EMP). Internationally competing firms may pay higher wages (EXQU). Moreover, also group membership (GROUP) and foreign ownership (FOREIGN) may play. Besides these variables, which are also included in the models assessing the impact of public funding on R&D expenditure and R&D employment, two other variables are defined to refine the assessment of additionality effects on R&D wages. First, the percentage of highly skilled employees is included as the share of R&D employees with a doctoral or university degree (UNI). Second, the impact of the union in the wage bargaining process may be an influencing factor. This parameter is computed following Vandenbussche et al. (2001). The idea is to maximise the union's utility function $U(w,L) = w.L$, explained by wages w and employment L, with respect to the wages:

$$\underset{w}{Max}\ \Omega = U^{\beta}\ .\pi^{(1-\beta)}\ . \tag{6}$$

The parameter β reflects the bargaining strength of the union, and has a value between zero, i.e. in the absence of a union: all rents are absorbed by the firm, and unit value, i.e. with a 'monopoly union': the union determines the wages unilaterally. Wages are modelled according to the following equation:

$$w = w^a + \frac{\beta}{1-\beta}\frac{\pi^0}{L^0}, \tag{7}$$

where the employee's wage is the sum of his alternative wage w^a and a fraction of the firm's profit per employee π^0/L^0. For each sector, an unbalanced firm-level panel was constructed, containing balance sheet information from the National Bank of Belgium (Belfirst), covering all Belgian firms in the sector, with non-missing values for the period 1998-2006. The profit π^0/L^0 was computed as the value added minus the labour costs, divided by the number of employees, and normalized by the consumer price index (obtained from Eurostat, 2008). The average wage w was generated dividing the total labour costs of the firm by the number of employees. The alternative wage w^a was set to zero[14]. As this model may be subject to endogeneity, the regression is instrumented by the profit per employee in the previous period π^0_{t-1} / L^0_{t-1} and year dummies. The monetary values were deflated (EconStats, 2007). Table 2 shows the estimated bargaining power coefficients β for the sectors in the dataset. Parameter β is additionally included in the equations where the impact of funding on R&D wages is estimated, in the variable BARG.

[14] Vandenbussche et al. (2001) alternatively suggest to set the alternative wage w^a at the sectoral minimum wage, but as this did not change their results, I also use a zero value for w^a.

Table 2: Estimated bargaining power coefficients

Nace	β	Number of companies	Nace	β	Number of companies
All sectors	**0.0623**	**224613**			
Manufacturing	**0.0890**	**148564**	27	0.1015	3794
15	0.1172	22345	271	0.0636	1565
16	n.s.	184	274	0.1415	765
17	0.0993	8355	28	0.0693	29427
18	0.1617	4819	29	0.0481	12105
19	0.1130	945	30	n.s.	941
20	0.1007	9113	31	n.s.	5270
21	n.s.	2913	32	n.s.	2463
22	0.0322	15396	321	n.s.	827
23	0.1885	352	33	n.s.	4240
24	0.1343	6971	34	n.s.	3276
244	0.1160	1358	351	0.1209	752
25	0.1108	6288	353	n.s.	283
26	0.0689	9367	355	n.s.	152
Services	**0.0146**	**76049**			
72	0.0325	18893			
722	n.s.	10603			
73	n.s.	1185			
74	0.0489	39684*			

*To facilitate computation, for sector 74 only a randomly selected subset of the total population (110846) companies was used. Note: in the models only twelve industry dummies are included, as some sectors were aggregated. However, as information on the exact 2-digit (for some subgroups 3-digit) sector affiliation is known for the companies, I decided to use all available information.

To test the presence of upskilling effects, a subgroup of the total R&D personnel, i.e. researchers (RDPR, in FTE) as well as the share of these researchers in the total R&D staff (RDPR/RDP, in %) are included as dependent variables.

As I use data from two pooled cross-sections and the average R&D expenditure was subject to a downward trend (see e.g. Debackere and Veugelers, 2007), a year dummy (YEAR=1 for the R&D 2006 wave) was included in each regression to control for differences over time. Moreover, the monetary variables[15] were deflated (EconStats, 2007). Extreme outliers with respect to the funding amount, R&D expenditure, R&D personnel and R&D wages were removed. The final sample consists of 470 observations. The summary statistics of the variables used to evaluate the input additionality of Flemish R&D subsidies are presented in Table 3.

[15] AMT, RDX, RDX_P/RDP, RDX_O/RDP, AMT/PROJ_past5yrs, CAPint and CASHF/EMP.

Table 3: Summary statistics dataset

	All companies									
	# Obs.	Mean	St. Dev.	Min.	Max.					
TREATMENT VARIABLES										
FUN (dummy)	470	0.3957	0.4895	0	1					
AMT (in mio EUR)	470	0.0744	0.1761	0	1.3284					
	Funded companies					**Non-funded companies**				
	# Obs.	**Mean**	**St. Dev.**	**Min.**	**Max.**	**# Obs.**	**Mean**	**St. Dev.**	**Min.**	**Max.**
OUTCOME VARIABLES										
RDX (in mio EUR)	186	0.9122	1.1911	0.0074	5.6797	284	0.5375	0.7699	0.0092	5.6544
RDXint (in %)	186	0.0987	0.1509	0.0004	0.7219	284	0.0499	0.0984	0.0000	0.7635
RDP (in FTE)	186	11.9277	14.8525	0.2000	72.4000	284	7.1340	9.8024	0.1000	79.8000
RDPint (in %)	186	0.2228	0.2586	0.0053	1	284	0.1321	0.1970	0.0019	1
RDX_P/RDP (in mio EUR / FTE)	186	0.0538	0.0282	0.0129	0.2157	284	0.0528	0.0290	0.0118	0.2118
RDX_O/RDP (in mio EUR / FTE)	186	0.0265	0.0258	0	0.1267	284	0.0217	0.0284	0	0.1800
INSTRUMENTS										
AMT/PROJ_past5yrs (in mio EUR)	186	0.0157	0.0579	0	0.5462	284	0.0014	0.0091	0	0.0889
PROJ/EMP_past5yrs (in number / FTE)	186	0.1355	0.3216	0	2.7500	284	0.0412	0.1710	0	2.0000
CONTROL VARIABLES										
lnEMP (in FTE)	186	4.0436	1.5037	0.69315	8.1928	284	4.2080	1.3968	0.69315	7.6159
PAT/EMP (in number / FTE)	186	0.4613	1.1672	0	7.2847	284	0.2882	0.9227	0	8.7338
EXQU (in %)	186	0.6135	0.3412	0	1	284	0.5768	0.3444	0	1
CAPint (in mio EUR / FTE)	186	134.8062	490.8716	1.26242	4856.3270	284	80.9283	125.6292	0.37779	790.2966
CASHF/EMP (in mio EUR / FTE)	186	16.0572	45.0683	-181.41	325.5137	284	17.3998	47.6177	-509.71	400.9867
GROUP (dummy)	186	0.5645	0.4972	0	1	284	0.6549	0.4762	0	1
FOREIGN (dummy)	186	0.2204	0.4157	0	1	284	0.2465	0.4317	0	1
YEAR (dummy)	186	0.5161	0.5011	0	1	284	0.5317	0.4999	0	1
ADDITIONAL VARIABLES										
UNI* (in %)	171	0.5874	0.2911	0	1	256	0.5700	0.3218	0	1
BARG (index)	186	0.0490	0.0485	0	0.1617	284	0.0629	0.0504	0	0.1885
RDPR** (in FTE)	175	7.0906	10.6564	0	60.0000	266	3.9445	6.5300	0	48.0000
RDPR/RDP** (in %)	175	0.5803	0.3229	0	1	266	0.5581	0.3479	0	1

Note: the details of BR are not presented here. To compute the logarithmic transformation values of AMT, RDX, RDP, AMT/PROJ_past5yrs and PROJ/EMP_past5yrs, zero values before the transformation were replaced by the minimum observed logarithmic value after the transformation.

5. Estimates

This section presents empirical evidence on the impact of R&D subsidies on R&D expenditure, employment and wages in Flanders. I employ parametric treatment effects models as well as IV regression models. First, the impact of the funding status is evaluated in a treatment effects framework. Table 4 reports the estimates of the selection equations. The amount of funding received as well as the number of projects submitted in the past are highly significant in the selection equation; they strongly influence the likelihood to receive public R&D funding in Flanders. This seems to indicate that there is a high level of continuity in the receipt of public funding.

Table 4: Treatment effects model: selection equations

	Probit estimates			Marginal effects			Probit estimates			Marginal effects		
AMT/PROJ_past5yrs	17.2055	(5.1059)	***	6.6760	(2.0125)	***						
PROJ/EMP_past5yrs	0.9137	(0.3595)	**	0.3545	(0.1397)	**						
lnAMT/PROJ_past5yrs							0.1958	(0.0953)	**	0.0742	(0.0363)	**
lnPROJ/EMP_past5yrs							0.2473	(0.0310)	***	0.0937	(0.0117)	***
lnEMP	0.0407	(0.0625)		0.0158	(0.0242)		0.0904	(0.0639)		0.0343	(0.0242)	
PAT/EMP	0.0268	(0.0680)		0.0104	(0.0264)		-0.0099	(0.0694)		-0.0038	(0.0263)	
EXQU	0.3598	(0.2057)	*	0.1396	(0.0799)	*	0.3752	(0.2188)	*	0.1422	(0.0829)	*
CAPint	0.0005	(0.0003)		0.0002	(0.0001)		0.0006	(0.0004)		0.0002	(0.0002)	
CASHF/EMP	-0.0003	(0.0014)		-0.0001	(0.0006)		-0.0001	(0.0015)		0.0000	(0.0006)	
GROUP°	-0.2299	(0.1528)		-0.0896	(0.0596)		-0.0540	(0.1637)		-0.0205	(0.0623)	
FOREIGN°	-0.2347	(0.1767)		-0.0894	(0.0658)		-0.1949	(0.1852)		-0.0725	(0.0673)	
YEAR°	-0.0572	(0.1261)		-0.0222	(0.0489)		-0.0759	(0.1325)		-0.0288	(0.0502)	
CONSTANT	-1.0552	(0.3649)	***				1.2089	(0.6561)	*			
BR	$\chi^2(11) = 20.13$		**				$\chi^2(11) = 14.72$					
Log-Likelihood	-278.8042						-247.2025					
Pseudo R^2	0.1163						0.2164					
# obs.	470						470					

° dy/dx is for discrete change of dummy variable from 0 to 1; *** (**,*) indicate a significance level of 1% (5, 10%)
The standard errors (between brackets) are obtained by the delta method.

Next, the outcome equations are estimated, taking the estimated coefficients from the selection equation (Table 4) into account. In doing so, the actual treatment effect is separated from the potential selection bias (in the HAZARD coefficient). In Table 5 the outcome estimates are presented. The receipt of a public R&D grant clearly has a positive impact on a company's R&D effort.

The results confirm positive additionality effects of R&D subsidies on R&D expenditure in Flanders, which is in line with previous analyses for Flanders (Aerts and Czarnitzki, 2004 and 2006 as well as Aerts and Schmidt, 2008). Funded companies spend more (RDX***) on R&D than their non-funded counterparts. Also, funding is positively correlated with the company's R&D expenditure intensity (RDXint***). However, as David and Hall (2000) put forward well-founded, this significantly positive impact on R&D expenditure may well be fully absorbed merely by researcher wage increases if the labour supply of R&D staffing is inelastic. Additional R&D expenditure would then not be translated into more R&D activity. The current analysis allows completing the additionality picture with information on the impact of public R&D grants on R&D employment and wages. First, we look at the impact on R&D staffing. Table 5 shows that similar companies with an opposite funding status significantly differ in terms of the R&D personnel they employ: the number of R&D employees (RDP***) as well as R&D personnel intensity (RDPint***) are significantly higher after the receipt of a subsidy. Hence, in Flanders, public R&D funding is actually translated into more R&D activity. These results suggest that the supply of R&D personnel in Flanders is not fully inelastic: companies are able to attract more R&D personnel when they have a larger R&D human resources budget at their disposal. This result contrasts with the findings of Suetens (2002), who could not provide evidence to support positive additionality effects of R&D subsidies to Flemish companies, evaluating the R&D staffing employed. This may, however, be due to the fact that the dataset as well as the analysis framework differ significantly (see David and Hall, 2000). Lastly, we turn to the potential impact of public R&D funding on a company's R&D wages (RDX_P/RDP). The estimates reveal that, in addition to a significantly positive impact on R&D expenditure and R&D staffing, also the wage structure reacts to an R&D subsidy: the average personnel cost per R&D employee (RDX_P/RDP*) increases, while the average operational costs and investments per R&D employee (RDX_O/RDP) do not change.

Table 5: Treatment effects model: outcome equations

	----------RDX [a]----------			----------RDXint [b]----------			----------RDP [a]----------			----------RDPint [b]----------			-------RDX_P/RDP[a]-------			-------RDX_O/RDP [a]-------		
HAZARD	-0.5911	(0.1968)	***	-0.0349	(0.0141)	**	-6.7083	(2.4905)	***	-0.0524	(0.0230)	**	-0.0114	(0.0067)	*	-0.0027	(0.0062)	
FUN	1.2007	(0.3180)	***	0.0768	(0.0217)	***	14.0455	(4.0166)	***	0.1259	(0.0352)	***	0.0181	(0.0108)	*	0.0101	(0.0099)	
lnEMP	0.3247	(0.0370)	***	-0.0273	(0.0044)	***	4.2379	(0.4671)	***	-0.0849	(0.0071)	***	0.0032	(0.0012)	**	0.0003	(0.0011)	
PAT/EMP	0.0292	(0.0415)		0.0019	(0.0048)		0.5808	(0.5240)		0.0062	(0.0078)		-0.0012	(0.0014)		-0.0015	(0.0013)	
EXQU	0.0855	(0.1358)		0.0471	(0.0154)	***	0.4880	(1.7134)		0.1032	(0.0251)	***	0.0060	(0.0046)		0.0086	(0.0042)	**
CAPint	0.0004	(0.0001)	**	-0.0000	(0.0000)		0.0031	(0.0018)	*	-0.0000	(0.0000)		-0.0000	(0.0000)		0.0000	(0.0000)	
CASHF/EMP	0.0031	(0.0009)	***	0.0001	(0.0001)		0.0220	(0.0113)	*	0.0005	(0.0002)	***	0.0001	(0.0000)	*	0.0001	(0.0000)	***
GROUP	0.1728	(0.1007)	*	0.0191	(0.0116)	*	1.5964	(1.2699)		0.0253	(0.0188)		0.0045	(0.0034)		0.0082	(0.0031)	***
FOREIGN	0.2157	(0.1070)	**	0.0138	(0.0126)		1.7087	(1.3500)		0.0076	(0.0205)		0.0042	(0.0036)		-0.0006	(0.0033)	
YEAR	-0.0203	(0.0790)		-0.0054	(0.0093)		0.6038	(0.9964)		0.0075	(0.0152)		-0.0055	(0.0027)	**	-0.0010	(0.0024)	
CONSTANT	-1.6781	(0.2228)	***	0.0801	(0.0256)	***	-19.5058	(2.8099)	***	0.3632	(0.0416)	***	0.0161	(0.0075)	**	0.0070	(0.0069)	
BR	$\chi^2(11) = 42.07$		***	$\chi^2(11) = 110.11$		***	$\chi^2(11) = 51.83$		***	$\chi^2(11) = 99.68$		***	$\chi^2(11) =31.82$		***	$\chi^2(11) = 14.92$		

Note: the industry dummy coefficients are not shown here; the test on their joint significance is reported, though. The standard errors (between brackets) are heteroskedasticly consistent.
The selection equation includes: [a] AMT/PROJ_past5yrs and PROJ/EMP_past5yrs - [b] lnAMT/PROJ_past5yrs and lnPROJ/EMP_past5yrs. Number of obs.: 470.

Table 6: IV regressions on the receipt of a subsidy

	----------RDX [a]----------			----------RDXint [b]----------			----------RDP [a]----------			----------RDPint [b]----------			-------RDX_P/RDP[a]-------			-------RDX_O/RDP [a]-------		
FUN	1.1852	(0.4087)	***	0.0797	(0.0273)	***	11.7621	(5.3633)	**	0.1581	(0.0837)	*	0.0290	(0.0128)	**	0.0124	(0.0085)	
lnEMP	0.3247	(0.0431)	***	-0.0273	(0.0044)	***	4.2396	(0.5819)	***	-0.0850	(0.0092)	***	0.0032	(0.0013)	**	0.0003	(0.0010)	
PAT/EMP	0.0297	(0.0384)		0.0018	(0.0036)		0.6619	(0.4653)		0.0051	(0.0060)		-0.0016	(0.0011)		-0.0016	(0.0014)	
EXQU	0.0879	(0.1412)		0.0466	(0.0181)	***	0.8282	(1.6535)		0.0984	(0.0288)	***	0.0044	(0.0055)		0.0082	(0.0044)	*
CAPint	0.0004	(0.0001)	***	-0.0000	(0.0000)		0.0035	(0.0018)	**	-0.0000	(0.0000)		-0.0000	(0.0000)		0.0000	(0.0000)	
CASHF/EMP	0.0031	(0.0013)	**	0.0001	(0.0002)		0.0217	(0.0135)		0.0005	(0.0003)	**	0.0001	(0.0000)	*	0.0001	(0.0000)	**
GROUP	0.1713	(0.0855)	**	0.0194	(0.0123)		1.3773	(1.1210)		0.0284	(0.0198)		0.0056	(0.0035)		0.0084	(0.0032)	***
FOREIGN	0.2151	(0.1270)	*	0.0139	(0.0146)		1.6280	(1.5233)		0.0088	(0.0198)		0.0046	(0.0038)		-0.0005	(0.0036)	
YEAR	-0.0207	(0.0772)		-0.0053	(0.0089)		0.5518	(0.9572)		0.0082	(0.0154)		-0.0052	(0.0029)	*	-0.0009	(0.0024)	
CONSTANT	-1.6748	(0.2538)	***	0.0795	(0.0213)	***	-19.0212	(3.3051)	***	0.3563	(0.0547)	***	0.0138	(0.0069)	**	0.0065	(0.0065)	
BR	$\chi^2(11) = 48.26$		***	$\chi^2(11) = 83.70$		***	$\chi^2(11) = 59.97$		***	$\chi^2(11) = 95.06$		***	$\chi^2(11) = 32.25$		***	$\chi^2(11) = 14.86$		
Instrument tests:																		
Anderson	$\chi^2(2) = 21.518$		***	$\chi^2(2) = 103.293$		***	$\chi^2(2) = 21.518$		***	$\chi^2(2) = 21.518$		***	$\chi^2(2) = 21.518$		***	$\chi^2(2) = 21.518$		***
Hansen-Sargan	$\chi^2(1) = 1.141$			$\chi^2(1) = 0.032$			$\chi^2(1) = 0.430$			$\chi^2(1) = 1.050$			$\chi^2(1) = 0.001$			$\chi^2(1) = 1.814$		
Centered R^2	0.2689			0.3561			0.3200			0.4736			-0.1040			0.1038		

Note: the industry dummy coefficients are not shown here; the test on their joint significance is reported, though. The standard errors (between brackets) are heteroskedasticly consistent.
The instruments used are: [a] AMT/PROJ_past5yrs and PROJ/EMP_past5yrs – [b] lnAMT/PROJ_past5yrs and lnPROJ/EMP_past5yrs. Number of obs.: 470.

The parametric treatment effects models reveal that the Flemish R&D policy stimulates private R&D activity, both in terms of expenditure and employment. In a next step, the evaluation of the funding status (FUN) is introduced in an IV framework. As discussed before, both the amount of funding received and the number of projects submitted by the company in the preceding five years are expected to be reliable instruments in an IV approach of the additionality issue. Table 6 shows the regression results. The coefficient of FUN is again highly significant and positive for R&D expenditure, personnel, intensity and wages. Moreover, the tests on the quality of the instrumental variables confirm that the model requirements hold. Compared to the treatment effects model, the coefficients are very similar.

In the last step, I extend the analysis of the funding status and take the amount of funding (AMT) into account. This enables a more profound insight into the nature of the additionality effects found in the discrete models. These latter models reject full crowding-out effects. However, it is still possible that funded companies to some extent replace private money with the public grant. This would mean that a subsidy partially crowds out companies' private R&D effort.

Again, funding is instrumented with both the amount of funding received and the number of projects submitted by the company in the preceding five years. The estimates for different R&D expenditure measures are presented in Table 7. The coefficient of AMT is highly significant and positive. Moreover, the tests on the quality of the instrumental variables confirm that the model requirements hold. A subsidy of 1 million EUR increases the average R&D expenditure with 1.793 million EUR. The Flemish R&D activities are highly skewed, however. That is why one should also consider lnRDX and RDXint. The coefficients of the log-log specification can be interpreted as elasticities. Here, the picture looks a little less attractive: the elasticity of the R&D expenditure merely amounts to 12%.

Table 7: IV regression: R&D expenditure

	----------RDX[a]----------			----------lnRDX[b]----------			----------RDXint[b]----------		
AMT	1.7927	(0.6528)	***						
lnAMT				0.1244	(0.0268)	***	0.0114	(0.0039)	***
lnEMP	0.3044	(0.0390)	***	0.4950	(0.0421)	***	-0.0282	(0.0043)	***
PAT/EMP	-0.0244	(0.0502)		0.0605	(0.0373)		-0.0020	(0.0036)	
EXQU	0.1703	(0.1170)		0.8621	(0.1401)	***	0.0512	(0.0181)	***
CAPint	0.0006	(0.0001)	***	0.0002	(0.0001)	***	-0.0000	(0.0000)	
CASHF/EMP	0.0034	(0.0011)	***	0.0034	(0.0011)	***	0.0002	(0.0002)	
GROUP	0.0666	(0.0599)		0.2690	(0.1045)	**	0.0164	(0.0120)	
FOREIGN	0.1464	(0.1065)		0.0546	(0.1218)		0.0102	(0.0145)	
YEAR	0.0315	(0.0673)		0.1417	(0.0889)		0.0034	(0.0095)	
CONSTANT	-1.3650	(0.1932)	***	-3.8667	(0.2830)	***	0.1642	(0.0342)	***
BR	$\chi^2(11) = 50.26$		***	$\chi^2(11) = 173.01$		***	$\chi^2(11) = 85.32$		***
Instrument tests:									
Anderson	$\chi^2(2) = 97.635$		***	$\chi^2(2) = 215.930$		***	$\chi^2(2) = 215.930$		***
Hansen-Sargan	$\chi^2(1) = 0.983$			$\chi^2(1) = 0.318$			$\chi^2(1) = 0.310$		
Centered R²	0.5134			0.5572			0.3777		

Note: the industry dummy coefficients are not shown here; the test on their joint significance is reported, though. The instruments used are: [a] AMT/PROJ_past5yrs and PROJ/EMP_past5yrs - [b] lnAMT/PROJ_past5yrs and lnPROJ/EMP_past5yrs. The standard errors (between brackets) are heteroskedasticly consistent. Number of obs.: 470.

Also the evaluation of the impact of public funding on R&D employment leads to similar results as the discrete treatment analyses. Again, the absolute increase is very high: a subsidy of 1 million EUR would result in the hiring of 17 additional R&D employees. The elasticity is 11%.

Table 8: IV regression: R&D employment

	----------RDP[a]----------			----------lnRDP[b]----------			----------RDPint[b]----------		
AMT	17.2735	(9.7748)	*						
lnAMT				0.1069	(0.0242)	***	0.0166	(0.0057)	***
lnEMP	4.0445	(0.5595)	***	-0.5784	(0.0390)	***	-0.0863	(0.0087)	***
PAT/EMP	0.1519	(0.6825)		0.0821	(0.0362)	**	0.0010	(0.0060)	
EXQU	1.6734	(1.4056)		0.5722	(0.1202)	***	0.1112	(0.0255)	***
CAPint	0.0055	(0.0013)	***	0.0002	(0.0001)	*	0.0000	(0.0000)	
CASHF/EMP	0.0245	(0.0134)	*	0.0018	(0.0009)	**	0.0006	(0.0002)	**
GROUP	0.3353	(0.8877)		0.1273	(0.0929)		0.0200	(0.0186)	
FOREIGN	0.9537	(1.4098)		0.0563	(0.1109)		0.0020	(0.0185)	
YEAR	1.0472	(0.9753)		0.2027	(0.0813)	**	0.0199	(0.0148)	
CONSTANT	-15.9628	(2.6074)	***	-0.4785	(0.2496)	*	0.4891	(0.0550)	***
BR	$\chi^2(11) = 62.38$		***	$\chi^2(11) = 190.68$		***	$\chi^2(11) = 120.75$		***
Instrument tests:									
Anderson	$\chi^2(2) = 97.635$		***	$\chi^2(2) = 215.930$		***	$\chi^2(2) = 215.930$		***
Hansen-Sargan	$\chi^2(1) = 0.919$			$\chi^2(1) = 0.986$			$\chi^2(1) = 1.118$		
Centered R²	0.4588			0.6479			0.5282		

Note: the industry dummy coefficients are not shown here; the test on their joint significance is reported, though. The instruments used are: [a] AMT/PROJ_past5yrs and PROJ/EMP_past5yrs - [b] lnAMT/PROJ_past5yrs and lnPROJ/EMP_past5yrs. The standard errors (between brackets) are heteroskedasticly consistent. Number of obs.: 470.

Table 9 confirms the earlier conclusion that also the wage structure is influenced by the R&D subsidy policy in Flanders. In the first model, only variables used in the models for RDX and RDP are included. The second model additionally includes two variables which may also exert a particular influence on R&D wages, i.e. the share of highly skilled R&D employees (UNI) and the union's strength in the wage bargaining process (BARG). The composition of the workforce (UNI***) indeed seems to drive a share of inter-firm wage dispersion, but the union (BARG) does not significantly affect R&D wages. This is not too surprising, as R&D employees are typically white-collar workers, who often receive pay supplements outside of collective agreements (Rusinek and Rycx, 2008). Therefore, the union's bargaining power is not relevant. This was already suggested in Table 2, where the bargaining power is less significant in sector 73: Research and Development. Obviously, the bargaining power is calculated from the total population of employees, but the share of R&D employees is expected to be high in this sector.

Table 9: IV regression: R&D wage structure

	RDX_P/RDP [a]			RDX_P/RDP [b]			RDX_O/RDP [a]		
AMT	0.0370	(0.0138)	***	0.0357	(0.0153)	**	0.0079	(0.0101)	
UNI				0.0124	(0.0050)	**			
BARG				0.0852	(0.0787)				
lnEMP	0.0028	(0.0012)	**	0.0028	(0.0013)	**	0.0002	(0.0010)	
PAT/EMP	-0.0026	(0.0014)	*	-0.0029	(0.0017)	*	-0.0016	(0.0014)	
EXQU	0.0068	(0.0048)		0.0037	(0.0050)		0.0097	(0.0042)	**
CAPint	-0.0000	(0.0000)		-0.0000	(0.0000)		0.0000	(0.0000)	
CASHF/EMP	0.0001	(0.0000)	**	0.0001	(0.0000)	**	0.0001	(0.0000)	**
GROUP	0.0030	(0.0030)		0.0042	(0.0030)		0.0072	(0.0030)	**
FOREIGN	0.0030	(0.0035)		0.0020	(0.0036)		-0.0011	(0.0036)	
YEAR	-0.0043	(0.0028)		-0.0038	(0.0029)		-0.0009	(0.0024)	
CONSTANT	0.0211	(0.0060)	***	0.0059	(0.0115)		0.0094	(0.0061)	
BR	$\chi^2(11) = 34.73$		***	$\chi^2(11) = 29.57$		***	$\chi^2(11) = 13.91$		
Instrument tests:									
Anderson	$\chi^2(2) = 97.635$		***	$\chi^2(2) = 81.767$		***	$\chi^2(2) = 97.635$		***
Hansen-Sargan	$\chi^2(1) = 1.194$			$\chi^2(1) = 1.166$			$\chi^2(1) = 2.719$		
Centered R^2	0.0762			0.0877			0.1101		

Note: the industry dummy coefficients are not shown here; the test on their joint significance is reported, though. The instruments used are AMT/PROJ_past5yrs and PROJ/EMP_past5yrs. The standard errors (between brackets) are heteroskedasticly consistent. Number of obs.: [a]470 [b]427.

So, bringing the results together, it is clear that public R&D funding induces additional R&D expenditure. Moreover, funded companies enlarge their R&D workforce. However, at the same time, the average R&D wage increases. Two potential explanations are advanced. On the one hand, the R&D wage increase may not involve any difference in productivity and result from an inelastic R&D labour supply. However, as the increase in R&D personnel after receiving a subsidy is considerable, the R&D labour supply in Flanders seems not to be fully inelastic. On the other hand, this R&D wage increase could signal an 'upskilling' process, i.e. the R&D workforce composition is shifted upwards with respect to its qualification. As only information on the average R&D wage is available, it is not possible to directly test this hypothesis. However, to some extent, a change in workforce composition can be assessed through other approximating variables. First, we look at the number of researchers. Compared with technicians and other R&D employees, it can be expected that they typically are more likely to be highly skilled. If we take into account that the total number of R&D employees increased with about 17.3 FTEs and compare this to the increase in the number of researchers only, which is about 16.7 (see RDPR in Table 10), it appears that the increase in R&D employment mainly comes from an increase in researchers. Further analyses (not shown here) indeed confirm that there is no significant increase in the number of technicians and other R&D employees. Second, I assess the impact of the subsidy on the share of researchers in the total R&D workforce (see RDPR/RDP in Table 10). Also here, a significantly positive impact can be found. In a cautious conclusion, one could therefore collect some evidence that the increase in R&D wages is not that detrimental, as the quality of the R&D employees tends to increase, which in turn increases the quality of the R&D activity, as well as the expected output.

Table 10: IV regression: number of researchers and their share in the total R&D workforce

	---------RDPR---------			---------RDPR/RDP---------		
AMT	16.7069	(7.6660)	**	0.3719	(0.1273)	***
lnEMP	2.5592	(0.4882)	***	-0.0284	(0.0143)	**
PAT/EMP	0.2066	(0.5348)		0.0146	(0.0159)	
EXQU	0.4368	(1.1295)		0.0322	(0.0564)	
CAPint	0.0010	(0.0007)		-0.0000	(0.0000)	
CASHF/EMP	0.0192	(0.0100)	*	0.0002	(0.0002)	
GROUP	0.1144	(0.6702)		0.0130	(0.0397)	
FOREIGN	-0.0039	(1.0194)		-0.0161	(0.0409)	
YEAR	0.9278	(0.7326)		0.0604	(0.0320)	*
CONSTANT	-10.5676	(2.0651)	***	0.6360	(0.0859)	***
BR	$\chi^2(11) = 47.62$		***	$\chi^2(11) = 12.59$		
Instrument tests:						
Anderson	$\chi^2(2) = 88.458$		***	$\chi^2(2) = 88.458$		***
Hansen-Sargan	$\chi^2(1) = 0.000$			$\chi^2(1) = 0.101$		
Centered R²	0.3970			0.0693		

Note: the industry dummy coefficients are not shown here; the test on their joint significance is reported, though. The instruments used are AMT/PROJ_past5yrs and PROJ/EMP_past5yrs. The standard errors (between brackets) are heteroskedasticly consistent. Number of obs.: 441.

6. Conclusion

Government intervention in private R&D activity is common practice nowadays. However, its impact may not be unambiguously positive, as presupposed by many governments. In the first place, one could ask whether R&D grants actually stimulate private R&D investments: companies may simply replace private R&D budgets with the public money provided by the government. This is the main question to which researchers try to find an answer in additionality research. However, even if an increase in private R&D investment is confirmed (as concluded by many scholars), this may not automatically induce more R&D activity: the additional R&D budget may be crowded out by duplicate or more risky research, or a mere increase in researcher wages without any impact on the R&D activity of a company and as a result render an R&D grant, although to the benefit of private R&D expenditure, ineffective.

This paper provides insights into the impact of R&D grants, giving audience to the appeal of David and Hall (2000) to include labour market dynamics in the traditional application of treatment effects models in additionality research. I empirically analyze the effect of public R&D subsidies on private R&D investments, employment and wages in Flanders, employing parametric treatment effects models and IV regression methods. The main data source is the Flemish R&D Survey, supplemented with information from companies' balance sheets (National Bank of Belgium), patenting activity (EPO) and subsidy history (IWT).

Size, previous innovative activity, international competition, group membership, foreign ownership and industry affiliation may induce a considerable selection bias, rendering the receipt of a subsidy endogenous. Controlling for this bias with information on the company's subsidy history, I conclude that R&D subsidies in Flanders bring about positive additionality effects, measured in R&D expenditure. Moreover, this public R&D funding is translated into more R&D activity: funded companies employ more R&D personnel, suggesting that the supply of R&D personnel in Flanders is not fully inelastic. Full crowding-out effects are rejected. However, partial crowding-out cannot be ruled out: funded companies do not add the whole subsidy amount to their private R&D budget. This analysis highlights the importance of evaluating the effectiveness of the R&D policy in terms of both the funding status and the grant size. The estimates indicate that, to some extent, the private R&D activity is reduced and replaced by the subsidy. The results for the impact on R&D expenditure and employment are very comparable; they change likewise.

However, next to a significantly positive impact on R&D expenditure and R&D staffing, also an increase in R&D wages is found in firms receiving R&D subsidies. A mismatch between the demand and supply of R&D employees may enforce an increase in labour costs for the companies, which translates in increased R&D remuneration. In the European Innovation Scoreboard (EIS) country reports, the drivers of innovative activity are assessed at the country level (PRO INNO EUROPE, 2007). Belgium is among the TOP10 in the EU27. Although it is clear that its performance lags behind in several indicators, and Belgium's weak competence in capitalizing the full benefits of above average levels of R&D and innovation expenditure in terms of innovative output is exposed, the main strength of the

Belgian innovation system seems to lie in its strong relative performance on human resources in innovation. Despite a small shortage of skilled technical staff in specific industries, especially in the Walloon region, and a considerable outgoing brain drain, which are denounced in the EIS report, the analysis in this paper shows that the Flemish human resources in innovation seem to be sufficiently strong to withstand an increase in the demand for R&D employees and to provide a significantly large supply in response. Conversely, also an upskilling process could be an underlying explanation for an increase in R&D wages after the receipt of a subsidy. As the increase in R&D employment is significant and as mainly the number of researchers is increased after a subsidy receipt, I tend to believe that a change in the composition of the workforce towards more highly skilled employees is the main force driving inter-firm R&D wage dispersion between funded and non-funded firms.

In these last paragraphs, I come to some final caveats which the reader should bear in mind and which give way to further research. First, the restriction to R&D active companies implies that the additionality effect can only be derived in terms of additional R&D spending. However, subsidies can be a trigger, pushing companies without any R&D activity to become R&D active. If these switchers would be taken into account as well, the treatment effects are very likely to be higher. Second, the literature review implies that the effect of an R&D subsidy may be very different in the long run. Here, short term effects were investigated. However, the increase in R&D activity on the short run may induce different effects on the long run. The impact on the R&D personnel demand may become even larger, when, as one could expect, the elasticity of labour supply is larger in the long run: more R&D personnel becomes available as idle R&D educated people switch to R&D jobs and new R&D educated people become available on the job market. Research on the long term effects would therefore add much value to the existing studies. Third, a profound analysis of the determinants of R&D wages is highly relevant. The composition of the workforce was revealed as a very important factor, while the union's bargaining power does not seem to play. However, an extension of the current model, including other potential determinants, seems a promising research field. Fourth, the variables reflecting the wage structure do not capture other benefits to reward R&D personnel. Examples are stock options or other fringe benefits. Taking these rewards additionally into account could refine the analysis currently presented here. However, this information is very difficult to obtain and highly company-specific. Last, it would be highly interesting to evaluate the R&D output effects of the increase in R&D activity. Some work has been done in this respect, using patenting activity (Czarnitzki and Licht, 2006 as well as

Schneider, 2008) or the introduction of new products (Aerts, 2008; Hujer and Radić, 2005 as well as Bérubé and Mohnen, 2007), but the topic deserves further elaboration. Also, the relationship between researcher wages and innovative performance seems to be a valuable research domain.

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